SOUTHERN INSECT MANAGEMENT LABORATORY USDA/ARS
Stoneville, Mississippi

Annual Report on Progress (CY 1996)
and
Plans (CY 1997)

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I. INTRODUCTION:

This report summarizes progress made on various research objectives in 1996 and presents plans for 1997.

Many of the results are preliminary and others are being released through established channels. Therefore, this report is not intended for publication and should not be referred to in literature citations.

The intent of this report is to give the reader an overview of Southern Insect Management Laboratory (SIML) research activities. These activities (progress and plans) address the laboratory and unit missions (listed on pages 4-6).

SIML activities are centered around seven research thrusts, which reflect present CRIS work units. These are:

1. Biological and genetic control and area-wide management of crop insect pests, emphasizing *Heliothis/Helicoverpa*;

2. Population ecology of insect pests for integrated control/ management systems;

3. Biology, ecology, behavior, and biological control of plant bugs, cotton aphids, and silverleaf whitefly;

4. Strategies for managing crop insects, emphasizing the cotton agroecosystem, pesticide effectiveness, and Bt resistance monitoring and management;

5. Integrated control of pecan pests;

6. Host plant resistance in soybean pests; and

7. Rearing of seven insect species in support of research around the world.

This report is divided into four sections:

1. Report on research progress in CY 1996;

2. List of publications including those in press and accepted for publication;

3. Other indicators of progress such as presentations and papers in manuscript; and

4. Plans for CY 1997.

In each section, items are arranged by researcher (in alphabetical order of lead scientist; the name of lead scientist and cooperating and/or collaborating researchers are provided for each item). If the reader has questions pertaining to the item, he/she should contact the individual scientist or laboratory director.

II. MISSION STATEMENTS AND STAFF:

SOUTHERN INSECT MANAGEMENT LABORATORY
ARS/USDA, Mid South Area
P. O. Box 346
Stoneville, Mississippi 38776
Telephone: Comm: 601-686-5231
FTS: 700-497-2231
FAX: 601-686-5421
Email: a03simstone@attmail.com

OFFICE OF LABORATORY DIRECTOR

MISSION:

The mission of the Southern Insect Management Laboratory is to conduct fundamental research on the biology, ecology, and rearing of field crop and pecan insect pests and their natural enemies; develop innovative biological, genetic, cultural, and chemical methods for suppressing insect pests; and integrate this knowledge into insect management systems, with emphasis on area-wide methods for *Heliothis/Helicoverpa*. A goal of this laboratory is to develop new and improved insect pest suppression strategies, including improvements in pesticide effectiveness, for population management approaches to improve crop production efficiency. Exotic organisms are received and cleared through the Stoneville Research Quarantine Facility for biological control of insects and weeds. Exotic predators and parasites are released and evaluated for establishment on field crop insect pests.

ARS PERSONNEL:

D. D. Hardee, Laboratory Director
T. G. Burton, Secretary AO
L. E. Taylor, Office Automation Assistant
J. D. Warren, Engineering Technician (Shop)

SOUTHERN INSECT MANAGEMENT RESEARCH UNIT

MISSION:

To develop new knowledge on the biology of field crop insects for development of new and improved control tactics and to establish fundamental principles for encouraging and using natural enemies more effectively. To develop and integrate insect suppression strategies into field crop and pecan systems that minimize the cost of plant protection, yet are ecologically acceptable. Specifically:

1. Elucidate the efficacy of indigenous predators and parasites, particularly those attacking the bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*.

2. Research and develop methods for augmenting parasite populations in management of insect pests of field crops, particularly parasitoids for control of *Heliothis/Helicoverpa*.

3. Develop new knowledge on biology and behavior of *Heliothis/Helicoverpa* spp. and beet armyworm, including use of entomopathogenic viruses in management of the latter.

4. Conduct basic biological and ecological research on plant bugs, particularly the tarnished plant bug, *Lygus lineolaris*, cotton aphid, *Aphis gossypii*, and the silverleaf whitefly, *Bemesia argentifolii.*

5. Develop monitoring and predictive technology through quantitative population ecology for field crop insect pests, particularly bollworm/budworm, tarnished plant bug, and cotton aphid.

6. Assess the role of early season host plants in the buildup of *Heliothis/Helicoverpa*, beet armyworm, and tarnished plant bug populations and devise new and innovative tactics for suppressing these populations, including use of entomopathogenic viruses in area-wide management of these pests.

7. Develop chemical/biorational control tactics for use in integrated systems.

8. Develop chemical, biological, and other nonchemical methods for control of insect and mite pests of pecans. Evaluate selections and native pecans for yield and adaptability to the mid-south.

9. Monitor for Bt resistance and develop resistance management tactics.

10. Locate, develop, and evaluate soybean cultivars resistant to insects.

ARS PERSONNEL:

D. D. Hardee, Research Leader, Laboratory Director
(Supervisory Research Entomologist)

L. C. Adams, Entomologist

M. R. Bell, Research Entomologist
D. W. Hubbard, Biological Science Technician

W. W. Bryan, Entomologist/Quarantine Officer
S. B. Ginn, Biological Science Laboratory Technician

L. Lambert, Research Entomologist
W. L. Solomon, Biological Science Technician

W. P. Scott, Research Entomologist
D. A. Adams, Biological Science Technician

M. T. Smith, Research Entomologist
R. A. Lemire, Biological Science Technician

G. L. Snodgrass, Research Entomologist
C. H. Lanford, Biological Science Technician

D. A. Streett, Research Entomologist

Vacancy, Research Entomologist
F. M. Williams, Biological Sciences Technician

Vacancy, Research Entomologist
Vacancy, Biological Science Technician

R. L. Ford, Biological Science Technician (Insect Rearing)
H. E. Winters, Biological Technician
G. J. Patterson, Insect Production Worker

III. SUMMARY OF RESEARCH PROGRESS FOR CALENDAR YEAR 1996:

A. *NARRATIVE:*

1. In-House

A transition year study designed to further investigate large area pest management techniques was conducted. This study required the organization and planning for treating a 25,000 acre test area 2 times with a formulation of nuclear polyhedrosis virus (NPV). In that test, the application coverage on the target plants was monitored, larvae collected from plants were examined to determine the incidence of infection, and insect emergence was examined through the use of field cages. Although the cage areas that received 2 applications of virus resulted in no adult moth emergence, the very low numbers of tobacco budworms and cotton bollworms emerging produced inconclusive results regarding the field cage data since the emergence was too low to be of significance. Although larvae were difficult to find on early season plants, 65% of those that were collected and examined were infected by the virus. **(M. R. Bell, D. D. Hardee, G. L. Snodgrass, D. A. Streett)**

Due to the devastating population of beet armyworms in Texas cotton in 1995, a large-plot field trial was planned and organized in cooperation with other ARS, APHIS, and Texas Boll Weevil Eradication Foundation scientists, designed to evaluate the effectiveness of the beet armyworm NPV for use in the control of that pest within the boll weevil eradication program in Texas, as well as the evaluation of its use in Mississippi cotton. The incumbent planned the test and arranged for the materials and equipment for the study. Although the populations were carefully monitored and the trapping data used in various reports at both locations throughout the season, the numbers of beet armyworms needed for field testing did not occur. **(M. R. Bell)**

The first year of a two-year field test to study the activity and incidence of beneficials in Bt cotton as compared to non-Bt cotton was begun in 24 field sites in Washington County, MS. Field collections were made weekly. The first season's data are being summarized for analysis. **(W. W. Bryan)**

Laboratory studies were conducted on an imported lepidopterous larval parasitoid, *Campoletis flavicincta* (Ashmead) (Hymenoptera: Ichneumonidae), imported from Argentina. Laboratory studies on the biology of this parasitoid were conducted to evaluate its effectiveness as a potential biological control agent for *Heliothis virescens* (F.), *Helicoverpa zea* (Boddie), and/or *Pseudoplusia includens* (Walker). Tests were conducted to evaluate host range, fecundity, and longevity of the parasitoid at 27°C, 60% RH, and a photoperiod of 14:10 LD. Results from the studies are currently being tabulated for analysis. **(W. W. Bryan)**

Production of insects for USDA-ARS research by the Stoneville Insect Rearing Unit required maintenance of seven insect species: *Heliothis virescens, Helicoverpa zea, Anticarsia gemmatalis, Pseudoplusia includens, Spodoptera exigua, Cardiochiles nigriceps,* and *Cotesia kazak*. Support of USDA-ARS scientists at Stoneville, Tifton, GA, Mississippi State, MS, College Station, TX, and Weslaco, TX, as well as state and industry scientists required production of 155,700 *H. virescens* pupae, 285,000 *H. zea* pupae, 141,000 *P. includens* pupae, 98,100 *A. gemmatalis* pupae, 146,000 *Spodoptera exigua* pupae, 146,000 *C. nigriceps* cocoons, 40,502 *C. kazak* cocoons, 106,049 *H. virescens* eggs, 38,925,000 *H. zea* eggs, 36,203,000 *P. includens* eggs, 895,800 *A. gemmatalis* eggs, and 36,650,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 99,570 plastic cups and 714 3.8 liter multicellular trays and artificial diet. Total diet mixed and dispensed in 1996 was 12,060 liters. Several short courses in insect rearing techniques were given to employees of: Abbott Laboratory, Chicago, IL and BASF, Greenville, MS. Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in Cotton Foundation and United Soybean Board Insect Distribution Programs. **(R. L. Ford)**

A second-year study of boll weevil emergence and movement of the boll weevil in the mid-delta of Mississippi showed that (1) boll weevils suffered a high degree of winter kill in 1995-96 in that numbers of emerging overwintered weevils were much lower in 1996 than in 1995; (2) these low numbers increased rapidly, however, in generations 1-3 to the point of high numbers in late season similar to 1995; and (3) as in 1995, considerable movement of overwintered and first generation weevils occurred after bloom as detected by pheromone traps, especially 1-3 miles from the closest cotton. Samples of weevils were retained from all traps for sex determination and pollen examination for host feeding detection. **(D. D. Hardee, Gretchen Jones, ARS, College Station, TX)**

Results from a test of two insecticide treatments (7 days apart) for cotton aphid on NuCotn 33 and Sure-Grow 125 at three different growth stages (pinhead square, full-grown square, first bloom) showed that (1) all 3 treatment stages in NuCotn 33 yielded more cotton than an untreated check, but bloom treatment was best; (2) no treatment of Sure-Grow 125 yielded significantly higher than the untreated check; and (3) NuCotn 33 yielded 197 lb lint per acre more than Sure-Grow 125. Sure-Grow 125 was treated once for bollworm/budworm; NuCotn 33 was not treated for worms; and both varieties received 6 treatments (2 at pinhead square; 4 in August) for boll weevil and tarnished plant bug. The test will be repeated in 1997. **(D. D. Hardee)**

Furadan at 0.25 lb AI/A and Provado at 0.047 lb AI/A provided significant reduction in cotton aphid numbers at 2, 5, and 7 days after treatment when samples were taken in the top and middle portions of the plant. Capsyn at 1 gal/50 acres (3300 Capsyn heat units) provided no significant reduction in aphid numbers when compared to an untreated check. **(D. D. Hardee)**

Data analyses are incomplete in a study comparing two biological insecticides (Javelin and Gemstar) applied at pinhead square to 3 fields each inside and outside a 7-mi circle treated early with Gemstar virus in an area-wide management program for bollworm/budworm. Weekly samples for all insects were made in 24 total fields (inside and outside virus area -- 3 reps each of Javelin, Gemstar, no treatment, and Bt-transgenic cottons). Data will be analyzed during the winter, and similar or slightly modified studies will be repeated in 1997. **(D. D. Hardee)**

Moth trap records in 1996 compared to 1995 data collected at the same trap sites showed that (1) beet armyworm numbers were 60% as high, (2) cotton bollworm numbers were over 3 times higher, and (3) tobacco budworms were 33% as high as 1995 numbers. The higher numbers of cotton bollworms and lower numbers of tobacco budworms beginning the season and increased corn acreage are two contributing reasons for higher cotton bollworm and lower tobacco budworm numbers during the 1996 season. **(D. D. Hardee)**

Preliminary *B.t.* resistance monitoring in cotton in populations of cotton bollworm (CBW) and tobacco budworm (TBW) was initiated in 1996 by (1) subjecting 23 different populations of these insects collected in Arkansas, Mississippi, Oklahoma, and Texas to field doses of MVP II biological insecticide in spray chamber bioassays

(the toxic protein in MVP II is the closest in toxicological properties of all *B.t.* insecticides to the Cry I A© protein expressed in transgenic coton), and (2) subjecting larvae of CBW and TBW from 4 sites in Mississippi to a diagnostic dose of MVP II administered in rearing diet. Preliminary monitoring results from both methods showed no shifts in baseline susceptibility levels of bollworm and budworm to *B.t.* insecticide (and by inference to *B.t.* cotton). **(D. D. Hardee, D. A. Streett)**

Evaluations were continued of twelve insect resistant soybean genotypes with different maturity dates to determine if resistance levels decrease during the fruiting phase or if later maturing genotypes develop higher levels of resistance. All genotypes have essentially the same level of resistance before fruiting. After the onset of fruiting the later maturing genotypes appear to have a higher level of resistance than earlier maturing genotypes. Through manipulation of photoperiod it was found that stage of development does influence levels of resistance. The studies are being conducted in a large field cage utilizing laboratory reared insects and light augmentation. **(L. Lambert)**

Studies were continued to evaluate the USDA-ARS soybean germplasm collection for resistance to insects. Evaluations with soybean looper and velvetbean caterpillar were conducted. In field cage evaluations of 1200 accessions, several genotypes were identified with high levels of resistance to foliar feeding by soybean looper or velvetbean caterpillar. The resistant accessions will be further evaluated and used in a breeding effort to develop soybean cultivars with high levels of resistance to insects. **(L. Lambert)**

Studies were continued on the inheritance and development of resistance to foliar feeding insects in soybean and to develop high yielding, insect resistant, group IV & V soybean cultivars. All lines were moved ahead one generation. **(L. Lambert, J. Tyler)**

Research was continued to identify resistance in cotton to foliar feeding by beet armyworm. This study will require two or more seasons to complete. **(L. Lambert, M. R. Meredith)**

Participated in annual evaluation of the Regional Host Plant Resistance Nursery of soybean for resistance to foliar feeding insects. Several genotypes in the nursery exhibit high levels of resistance to foliar feeding insects. **(L. Lambert)**

A large field plot study to compare sampling (sweep net, drop cloth, and visual) and economic thresholds for tarnished plant bug control that are currently recommended in the Insect Control Guide were evaluated in Stoneville 474 cotton. Extremely low populations of plant bugs occurred in test field in 1996 prior to initiation of bollworm sprays. **(W. P. Scott, G. L. Snodgrass)**

Spray table tests were conducted with Fipronil (Rhone Poulenc) on resistant tarnished plant bug populations. Two formulations of Fipronil (commercial formulations) showed excellent activity on resistant plant bugs. **(W. P. Scott, G. L. Snodgrass)**

A large field plot study to study the effects of seed treatments, in-furrow and sidedress treatments on early season insect populations and yield were evaluated in Bt and SureGrow 501 cotton varieties. Populations of early season insects were low in 1996 and were not influenced by any particular treatment. Although tarnished plant bug numbers were low, higher populations occurred in the Bt cotton. Treatments with in-furrow applications of Temik and Admire and sidedress Temik applications had higher yields than Gaucho and Orthene seed treatments. **(W. P. Scott)**

A small plot cage study was conducted to determine the efficacy of Guthion 2L, Guthion 3F, Vydate, Methyl Parathion, and Fipronil on the boll weevil. Sleeve cages were used to hold weevils on treated cotton plants. When compared to an untreated check there was no difference between treatments when weevils were caged immediately after treatment and mortality read after 24 h exposure. The highest mortality at 48 h of weevils that were caged 1 day post treatment occurred in the Fipronil, Guthion 2L, Guthion 3F, Vydate, and methyl parathion treatments, respectively. **(W. P. Scott)**

Populations of the tarnished plant bug were studied in DES 119 nectaried and DES 119 nectariless cottons. Low populations of plant bugs were observed through July in both cotton plantings. Higher first pick yields were observed in the 119 nectariless cotton. There were no differences in total yield. **(W. P. Scott, G. L. Snodgrass)**

The fourth year of a research project was continued in which the goal is to develop an integrated pest management (IPM) system for control of stink bugs in pecans. This IPM system is centered around a trap cropping strategy designed to intercept stink bugs as they migrate from soybean and other host plants into pecan orchards. This system is also designed to be integrated with management of these pest

species in commonly associated cropping systems, soybeans in particular. Implementation of this system is dependent upon the development of new information regarding: (1) development of monitoring methods for determining the primary periods of stink bug migration between the source crops (i.e. soybeans) and pecan; (2) identification of trap crop plants which are optimally synchronized with stink bug migration into pecan; (3) qualitative and quantitative evaluation of stink bug damage to pecan which is based upon pecan nut developmental phenology and stink bug population density (thresholds); and (4) development of methods (biological and chemical) to control stink bugs: (a) in the source crops prior to their emigration from the source crop, (b) in the trap crop prior to their emigration from the trap crop, and © in the pecan orchard. The specific objectives addressed in the 1996 experiments were: (1) to evaluate the effectiveness of speckled purple hull pea (SPHP), planted as a trap crop along the margin of a pecan orchard, to reduce stink bug feeding damage in pecan (second year of an experiment initiated in 1995); (2) to evaluate and compare SPHP and zipper cream pea (ZCP) in regard to their phenological synchronicity with stink bug migration from soybeans and with pecan harvest; and (3) to determine the precise association of soybean developmental phenology and harvest with stink bug migration. All stink bug sampling data clearly indicate that population levels in soybeans, peas (SPHP, ZCP) and pecan trees were very high during the 1996 season. In objective #1, monitoring of vegetative and fruit phenology in both the soybeans and SPHP was performed. While the 1995 data indicated that SPHP continued to produce attractive pods until first frost, (which coincided with pecan harvest in mid-November), production of flowers and attractive pods terminated earlier during 1996. This may have been due in part to the very dry July and August periods in this orchard. Drop cloth sampling in the soybeans and SPHP enabled detection of peak stink bug migration periods and development of their offspring. Control of stink bugs within the peas was again investigated during 1996, with applications of Sevin and Phaser mixtures applied prior to the potential emigration (via wing development in the adult) of the F_1 generation out of the trap crop and into the test orchard. Pre- and post-treatment monitoring of stink bug population levels indicated an acceptable level of stink bug control in the trap crop. Finally, assessment of stink bug feeding damage to pecans is currently in progress, and therefore, trap crop efficacy is uncertain. However, visual observations of stink bugs in the orchard prior to and during nut harvest, the very high stink bug population levels in samples taken from the soybeans and trap crop, and the premature termination of pod production in the trap crop, collectively

lead us to speculate that stink bug feeding damage may be very high in the pecan orchard adjoining both the trap crop and control plots. **[M.T. Smith, B. Horton (pecan grower), M. Hughs (pecan grower), G. L. Snodgrass]**

Results from objective #2 have not yet been analyzed, as field data collection has not been completed. However, both pea varieties continued to produce attractive pods into late season, synchronizing with both stink bug migration and pecan harvest. Plant growth structure was distinctly different in the two varieties, with SPHP producing taller, more lush vegetative growth which generally shaded the pods, while ZCP produced shorter vegetative growth with pods extending above the plant foliage. Although stink bug population data have not as yet been analyzed, this differential plant growth structure may indicate that SPHP is preferred by stink bugs due to its shaded pods. **[M.T. Smith, T. Winters (pecan grower), T. Jenkins (pecan grower), G. L. Snodgrass]**

Although data analyses are in progress, knockdown spray results from objective #3 indicate that stink bug migration to pecan is closely associated with maturity and harvest dates of soybeans. Therefore, a late maturity group soybean planted commercially may delay stink bug migration out of the soybeans, or planted as a trap crop may delay stink bug migration into the pecan orchard. **[M.T. Smith, T. Winters (pecan grower), T. Jenkins (pecan grower), G. L. Snodgrass]**

Research was continued on the sex pheromone of the hickory shuckworm (HSW), a key nut pest of pecan. The goal of this project is to develop an integrated pest management (IPM) system for control of the HSW in pecans. This IPM system is centered around a sex pheromone based strategy and is designed to: (1) provide a reliable monitoring method of the seasonal and spatial population dynamics of the HSW; (2) suppress HSW population levels and pecan nut losses by disrupting mating; (3) provide a floating HSW action threshold based upon the qualitative and quantitative evaluation of HSW damage to pecan as a function of pecan nut developmental phenology and HSW population density; and (4) develop methods (biological and chemical) for direct HSW control. All tests are being conducted at three locations across the pecan belt of North America in order to obtain results under different environmental conditions, management systems and shuckworm pressure: Camargo, Mexico represents an arid dessert environment in which irrigation is essential but limited by availability, where pesticides are utilized under a narrow

profit margin, and where shuckworm populations can build to enormous levels; the Mississippi Delta orchard represents a hot and humid environment where irrigation is lacking, where the orchard is maintained under a biological control, non-pesticidal management program, and where shuckworm populations are high in early season and relatively low to intermediate in late season; and the central Georgia orchard also represents a hot and humid environment where irrigation is often available, where the orchard is under a more intensive management program (including traditional spraying for various insect and disease pests), and where shuckworm populations tend to be high in early season and quite variable in late season. Compilation of data from a series of sex pheromone formulation tests (1993-1995) was completed and analysis is in progress **[M.T. Smith, G. Gries (Simon Fraser University), Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower)]**

Results from preliminary field studies in 1993 indicated that the hickory shuckworm (HSW) may not be uniformly distributed within a pecan orchard. Therefore, more definitive investigations were performed in 1994, 1995 and 1996 with respect to the spatial and seasonal distribution of the hickory shuckworm moth within pecan orchards as determined by pheromone trap catch. Data analysis is in progress, but the '94 and '95 data strongly suggest a clumped distribution of the HSW within pecan orchards. Some data also suggest the potential of clumping within individual tree canopies. This new information will be used to determine the appropriate time to initiate and terminate shuckworm monitoring, as well as the appropriate number of pheromone traps per unit area that will provide a reliable estimate of moth presence and density. Weather data are also being collected at each site in order to correlate HSW population trends with key climatic parameters. Eventually, population level thresholds, which undoubtedly vary as a function of nut phenology, will be developed. **[M.T. Smith, Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower), Jeff White (Ecogen)]**

Preliminary mating disruption investigations of HSW were initiated in 1994. Spiral and sprayable formulations of the disruptant were prepared. Mating disruption tests conducted in 1995, utilizing the spirals, appeared to strongly indicate that it is possible to shut down pheromone trap attractancy to male moths by the deployment of mating disruption spirals in both the upper and lower areas of the pecan tree canopy. This occurred at all three test orchards, which were under differing shuckworm population pressures. Data were also obtained in an "Aging" study of the mating disruption spirals in

order to determine the expected longevity of their efficacy. The specific objectives in 1996 were: (1) to evaluate the placement of the mating disruptant within the tree canopy; (2) to evaluate the dosage of the mating disruptant; and (3) to evaluate the comparative efficacy of two mating disruptant formulations, spirals and sprayable, to disrupt mating. Evaluation of mating disruptant efficacy was based upon the measurement of three parameters: (1) numbers of male moths trapped within sex pheromone baited traps; (2) percentage of female mated moths; and (3) nut damage. As these tests are still in progress, presentation of results at this time would be premature. However, preliminary nut damage data clearly indicate the importance of nut developmental phenology in the establishment of HSW infestation thresholds (as pecan shucks heavily infested with HSW during late season showed little or no kernel damage in the Mississippi test orchard). **[M.T. Smith, Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower), Jeff White (Ecogen)]**

Research is focused on the development of biological control for the management of the *Bemisia* complex of whiteflies infesting key agronomic crops in the United States [i.e. cotton, vegetables (melons and tomatoes), ornamentals, etc.]. Studies have concentrated on the evaluation of the factors affecting parasitoid efficacy, specifically temperature and host plant. Initial studies (1994-1995) provided evidence for two climatic strains of *Encarsia formosa* (one from Greece and another from Egypt), the most widely utilized and commercially available parasitoid of whiteflies throughout the world. These studies clearly indicated the importance of searching for parasitoids which originate from areas with climates similar to the climates in the targeted areas for release or introduction. **(M. T. Smith, R. Hennessey)**

Based upon these results, APHIS and several university scientists in the northeast United States conducted cooperative greenhouse studies in 1996, evaluating the Egypt strain of *E. formosa.* Collectively, our results and the results from these greenhouse studies have led to an effort to develop a CRADA between APHIS, ARS and private industry. This effort is currently in progress. **[M. T. Smith, M. A. Ciomperlik (APHIS), L. E. Wendel (APHIS), Mike Morton (HydroGardens)]**

Subsequent studies (1995-1996) evaluated the effect of host plant on parasitoid efficacy. These studies included four strains of *E. formosa* (Greece strain, Egypt strain, Commercial strain, Beltsville strain), and a diverse group of economically important host plants (cotton,

cabbage, tomato, bean, cantaloupe, hibiscus, poinsettia). Parasitoid biological parameters measured included adult longevity, life long fecundity and percent parasitism, as well as parasitoid developmental rate and percent emergence. While *Bemisia argentifolii* 3rd instar nymphs were evaluated, whitefly eggs and early instar nymphs were also provided since these life stages are utilized as food by adult parasitoids. Host plant leaf area and hair density were measured as potential factors which may affect searching efficacy of the adult parasitoids, and therefore the various biological parameters. Data analysis is in progress. **[M. T. Smith, M. Ciomperlik (APHIS), J. Neal (ARS), M. Morton (HydroGardens)]**

Currently, a cooperative effort is focused on the evaluation of interspecific interactions among parasitoid species being considered for utilization in the suppression of the silverleaf whitefly. A grant proposal is near completion and will be submitted. **[M. T. Smith, S. Naranjo (ARS), G. Jackson (ARS), M. Hunter (University of Arizona, Tucson)]**

In concert with these parasitoid evaluations, and as a prerequisite to subsequent field evaluation and release programs, a survey of the whitefly and associated parasitoid species in Mississippi was initiated in 1995 and expanded in 1996. Similar surveys have been conducted or are in progress in other states in southern U.S. Much effort was made to establish and coordinate collection of whitefly infested plant samples from throughout the state, with APHIS, the Mississippi State University Agricultural Extension Service, and private industry. In 1995, 179 samples were collected and four whitefly species tentatively identified (greenhouse whitefly, bandedwinged whitefly, sweetpotato whitefly and silverleaf whitefly. Whiteflies were found infesting a wide variety of ornamentals (17 species), vegetables (10 species), cotton (various varieties), soybeans (various varieties), and various weed species extending across 17 counties. Parasitoids were collected from 72% of the 179 samples. Results from the 1996 survey are currently being tabulated and analyzed. To date, however, a total of 271 samples has been collected from 25 counties in 1996. Samples have been collected from a total of 48 plant species, including cotton, soybean, 6 vegetable species, 26 field ornamental species, and 14 greenhouse ornamental species, representing 45.4%, 11.1%, 7.7%, 18.5% and 17.3%, respectively, of the samples collected. Whiteflies were found infesting 68.3% of the plant samples collected, and were found in all 25 counties. Whitefly identifications (based upon nymphal morphology and the expression of the silverleaf symptoms in zucchini) indicated that the same 4 whitefly species

found in 1995 were again present in 1996. Whitefly-infested plants were predominantly bandedwinged whitefly (55.7%), followed by sweetpotato whitefly (22.7%), greenhouse whitefly (11.9%), and silverleaf whitefly (9.7%). In particular, silverleaf whitefly was collected from: tomato (greenhouse), hibiscus and pansies (greenhouse), and henbit, creeping lavender lantana, candlelabra tree, hibiscus (Lord Baltimore), native rudbeckia, night shade, pansies, rudbeckia hirta, and tropical soda apple (field ornamentals). Finally, parasitoids emerged from only 11.4% of the whitefly-infested plant samples collected. The majority of the parasitized whiteflies were bandedwinged whitefly collected from cotton and soybean fields. The low overall incidence of parasitization is likely due in part to low whitefly density levels, as well as the differing pesticide use patterns in the various cropping systems. Parasitoid identifications and continuation of this survey will be performed during 1997. A detailed discussion of the results will be prepared following a more thorough analysis of the data (including comparison with 1995 data). With assistance and training from Dr. Greg Evans (whitefly parasitoid taxonomist at the University of Florida, Gainesville) during 1996, identification of parasitoid specimens collected during both years is in progress. This survey will continue through 1997. **[M. T. Smith, M. Allred (APHIS), M. Ciomperlik (APHIS), B. Layton (MSU), R. Snyder (MSU), P. Harris (MSU), S. Nakahara (USDA), G. Evans (DPI/UF)]**

Efforts were continued in the development of collaborative research with Dr. Regina Vilarinho de Oliveira (EMBRAPA, CENARGEN, Brasilia, Brazil), where the primary object is to explore for and evaluate New World parasitoid species in Brazil for control of *B. argentifolii.* A grant proposal, authored by Dr. Oliveira, was submitted to EMBRAPA and CNPQ following our joint meetings at the SICOMBIOL held in Brazil during June 1996. **(M. T. Smith)**

A survey of the Arkansas, Louisiana, and Mississippi Delta was conducted again in the spring (April-May) and fall (September-October) of 1996 to determine how widespread pyrethroid resistance was in tarnished plant bug populations in the Delta. The study was a repeat of the survey conducted in 1995 and used the same collection locations and time periods in both years. At least 50 adult tarnished plant bugs from each of 71 locations (6 in Louisiana, 17 in Arkansas, and 48 in Mississippi) were tested for pyrethroid resistance in the spring and fall. The bugs were exposed in glass vials (2 adults per vial) treated with a discriminating dose of 15 μg of permethrin for a 3-h period after which mortality was determined. Susceptible

populations (mortalities >90%) were about the same in number in the spring with 30 and 32 of the locations having susceptible populations in 1995 and 1996, respectively. In the fall only 11 and 6 locations in 1995 and 1996, respectively, had susceptible plant bug populations. These results showed that pyrethroid resistance was widespread in the Delta and was increased in both years from spring to fall by selection pressure with pyrethroid use in cotton. The decrease in resistance seen in both years from fall to spring was due to the resistance being recessive and the production of 3-4 plant bug generations on wild hosts out of cotton during September-November and April-May of the following year. **(G. L. Snodgrass, W. P. Scott)**

A colony of plant bugs having unusual bright red eyes was reared through 1996 in the laboratory and the inheritance of the red-eyed trait was studied. The trait was found to be due a single recessive gene which was not sex-linked. To determine the occurrence of the red-eyed trait in nature, all adults and nymphs collected in the resistance survey of the Delta (discussed above) during the fall of 1995 and in the spring and fall of 1996 were examined for the red-eyed trait. A total of 15,697 adults and 8,904 nymphs were examined, and no red-eyed individuals were found. Fitness of the red-eyed bugs in the laboratory (egg production, percent egg hatch, nymphal developmental time, nymphal survival) was found to be the same as normal eyed bugs. **(G. L. Snodgrass)**

A large plot field test designed to evaluate treatment thresholds currently recommended by the Mississippi Cooperative Extension Service for the control of tarnished plant bugs in cotton, was conducted on a growers farm near Indianola, MS. Unfortunately, plant bug numbers found in the plots during June and July were too low to properly evaluate the test. **(G. L. Snodgrass, W. P. Scott)**

I was transferred to the Southern Insects Management Laboratory (SIML) in May 1996. My current research activities encompass two general areas: 1) epizootiological studies of insect diseases in field crop populations; and 2) formulation and field evaluation of entomopathogens for the control of field crop pest populations. Prior to my arrival at SIML, I was a Research Entomologist at the Rangeland Insect Laboratory, Bozeman, Montana, with a specialization in the field of insect pathology. My research has focused on identification and formulation of grasshopper pathogens, epizootiology, and microbial control of grasshoppers. I will be reporting on my research at the Rangeland Insect Laboratory this past year. **(D. A. Streett)**

A naturally occurring indigenous pathogen of *C. pellucida* was identified during the 1994 outbreak of the grasshopper, *Camnula pellucida* in the Klamath Marsh, Oregon area. This pathogen was later identified as a microsporidian parasite. An augmentative release of the *Camnula* microsporidium was made using contaminated grasshopper feces during the 1995 field season. The parasite was successfully transmitted to late instar *C. pellucida* nymphs at the release site. Although disease transmission occurred, the presence of late instar nymphs at the release area probably limited transmission due to dispersal of adults. An augmentative release of the *Camnula* microsporidium against early instar nymphs may be more effective. **(D. A. Streett)**

During a survey of grasshopper populations in the western United States a naturally-occurring population of *Nosema locustae* was detected near New Harmony, Utah. A low prevalence (0.8%) was first detected in fourth instar *Oedaleonotus borckii*, a species that hatches in early spring. *N. locustae* was then detected in two other grasshopper species, *M. sanguinipes* and *M. packardii*, at prevalence levels of 2.0% and 7.4%, respectively. In the following field season, grasshoppers infected with *N. locustae* were not observed until late in the field season. This was attributed to the relatively low numbers of the susceptible early season species, *O. borckii*. **(D. A. Streett)**

2. <u>Extramural</u>

Virus production continued in a cooperative agreement with DuPont in which various insect viruses were produced for formulation to determine various improvements in characteristics of the virus for use as microbial insecticides. **(M. R. Bell, D. A. Streett)**

A study was conducted in cooperation with the University of Arkansas to determine the effect of certain plant hosts of the tobacco budworm and cotton bollworm the Mississippi Delta on virus persistence. A commercial formulation of the baculovirus from the cotton bollworm (Gemstar) was applied to crimson and white clover, and to cutleaf wild geranium. Tobacco budworms feeding on white clover collected at 0, 1, 3, and 6 days post-treatment with virus produced virus-induced mortalities of 77, 31, 13, and 2 percent, respectively. Mortality due to virus did not differ significantly from the control after 3 days. Virus-induced mortality on treated wild geranium indicated 73 percent mortality on day 0 and 38 percent on day 3. These results did not correspond well to earlier studies where 47 percent mortality was demonstrated 9 days after application. Since the virus preparations

were different, further studies will have to be conducted to evaluate not only the persistence, but the virus formulations and products as well. **(M. R. Bell)**

Continued in cooperative studies to determine the significance of sound production of fire ants. Several types of sound generated by fire ants have been identified. **(L. Lambert, R. Hickling)**

B. *INDICATORS OF PROGRESS:*

1. Publications (Published, In Press, Accepted)

Calkins, C. O., R. M. Faust, J. R. Coppedge, J. F. Brunner, L. D. Chandler, D. D. Hardee, and M. R. Bell. 1996. Areawide IPM as a tool for the future. Proc. 3rd National IPM Symposium (In Press).

Hardee, D. D. 1996. Resistance management in the Mid South -- cotton aphid: current status as a pest of cotton. Proc. Cotton Inc. Seminar on Resistance, Cotton Incorporated, Raleigh, NC.

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Scott, W. P., and G. L. Snodgrass. 1996. Efficacy of Fipronil and Provado against tarnished plant bugs in cotton, 1994. Arthropod Management Tests 21: 268.

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Snodgrass, G. L., and W. P. Scott. 1996. Pyrethroid resistance in overwintered and first generation tarnished plant bug populations in the Mississippi River Delta. Proc. 42nd Annual Mississippi Insect Control Conf. (Abstract).

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Streett, D. A., and J. E. Henry. 1996. *Endoreticulatus aulocarae* n. sp. (Protozoa: Microspora), a microsporidium infecting the grasshopper *Aulocara elliotti* (Orthoptera: Acrididae). Parasitol. Res. Accepted 7/96.

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Tillman, P., and L. Lambert. 1996. Influence of soybean pubescence on incidence of the corn earworm and the parasitoid, *Microplitis croceipes*. Southw. Entomol. 20: 181-185.

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2. <u>In Manuscript</u>:

Bryan, W. W., D. A. Herbert, Jr., and D. D. Hardee. Evaluation of three oviposition methods, three different host densities, and mortality factors in a M*icroplitis croceipes* rearing program. (In peer review)

Bryan, W. W. and D. A. Herbert, Jr. The effect of four soil types on depth bored by *Microplitis croceipes* parasitized and unparasitized *Helicoverpa zea* larvae in the laboratory and greenhouse. (In peer review)

Bryan, W. W. and D. A. Herbert, Jr. Effect of soil tillage practices on *Microplitis croceipes* cocoon location in the field. (In peer review)

Bryan, W. W. and D. A. Herbert, Jr. Opportunities for manipulation of *Microplitis croceipes* in first generation *Helicoverpa zea*: A survey of wild and cultivated early season host plants in Virginia. (In peer review)

Bryan, W. W., and F. M. Williams. Biology and laboratory rearing of *Campoletis flavicincta* (Hymenoptera: Ichneumonidae), an imported larval parasitoid of several lepidopterous pests. (In preparation)

Erlandson, M., and D. A. Streett. Entomopoxviruses associated with grasshoppers and locusts: Biochemical characterization. Mem. Can. Soc. Ent. (Submitted for publication).

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Hostetter, D. L., and D. A. Streett. Grasshopper pathogens and IPM. USDA/APHIS Technical Bulletin No. 1809. (In preparation).

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Scott, W. P. The influence of early season treatments on insect populations and yield in Bollgard (96 BG-1) and SureGrow 501 cotton varieties. Proc. 1997 Beltwide Cotton Prod. Res. Conf. (In preparation)

Smith, M. T., and R. D. Hennessey. Evaluation of two strains of *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* (Homoptera: Aleyrodidae), on hibiscus: Bionomics in relation to temperature. Biological Control. (In review)

Smith, M. T., D. J. Lanham, and R. D. Hennessey. *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* Bellows & Perring (Homoptera: Aleyrodidae): Behavioral analysis of two geographic populations in relation to temperature. Biological Control. (In review)

Smith, M. T., J. Neel, and M. Ciomperlik. Evaluation of four strains of *Encarsia formosa* Gahan as parasitoids of *Bemisia argentifolii* (Bellows and Perring) on different host plants. Biological Control. (In preparation)

Smith, M. T., D. J. Lanham, and W. Hays. Behavioral modeling of *Encarsia formosa* Gahan as a parasitoid of *Bemisia argentifolii* Bellows and Perring under different temperature regimes. J. Insect Behavior. (In preparation)

Smith, M. T., S. Galindo, and C. Yonce. Spatial distribution and seasonal dynamics of the hickory shuckworm (*Cydia caryana*). Environ. Entomol. (In preparation)

Smith, M. T., and J. White. Threshold release rate of the hickory shuckworm (*Cydia caryana*) sex pheromone from mating disruption spirals. Econ. Entomol. (In preparation)

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Smith, M. T., P. Harris, R. Snyder, and B. Layton. Survey of whitefly and associated parasitoid species in Mississippi. Econ. Entomol. (In preparation)

Smith, M. T. Spatial distribution and movement of stink bugs in pecan. Environ. Entomol. (In preparation)

Smith, M. T. Evaluation methods for stink bug damage in pecan. Econ. Entomol. (In preparation)

Smith, M. T. Evaluation of trap crop plant species for control of stink bugs in pecan. Environ. Entomol. (In preparation)

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Smith, M. T., C. C. Reilly, and B. W. Wood. Developmental and reproductive performance of the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell) and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on the North American species of the Juglandaceae: A study of aphid-plant coevolution. Environ. Entomol. (In preparation)

Smith, M. T., R. F. Severson, C. C. Reilly, and B. W. Wood. Host-plant selection by the blackmargined aphid *(Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell) and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on the North American species of the Juglandaceae: A comparative study of foliar cuticular chemistry and host-plant recognition. J. Chem. Ecol. (In preparation)

Smith, M. T., C. C. Reilly, and B. W. Wood. Developmental and reproductive performance of the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell) and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on a select group of pecan cultivars. Environ. Entomol. (In preparation)

Smith, M. T., R. F. Severson, C. C. Reilly, and B. W. Wood. Host-plant selection by the blackmargined aphid *(Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell) and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on a select group of pecan cultivars. J. Chem. Ecol. (In preparation)

Smith, M. T., R. F. Severson, and R. C. Gueldner. Seasonal dynamics of the surface chemistry of pecan leaves, rachis and nut. J. Agric. Food Chem. (In preparation)

Smith, M. T., R. F. Severson, and R. C. Gueldner. Seasonal dynamics of the whole tissue chemistry of pecan leaves, rachis and nut. J. Agric. Food Chem. (In preparation)

Smith, M. T., C. C. Reilly, B. W. Wood, and R. Paul. SEM analysis of leaf surface morphology of the Juglandaceae native to North America: Implications in host plant resistance to pecan aphids. Environ. Entomol. (In preparation)

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Snodgrass, G. L. Distribution of the tarnished plant bug (Heteroptera: Miridae) within cotton plants. Environ. Entomol. (In preparation).

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Streett, D. A., and J. R. Fisher. Epizootiology of *Nosema locustae* in grasshoppers. J. Invertebr. Pathol. (In preparation).

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Streett, D. A., and S. A. Woods. *Beauveria bassiana* for Mormon crickets. USDA/APHIS Technical Bulletin No. 1809. (In preparation).

Streett, D. A., E. A. Oma, and J. E. Henry. Genotypic variation among entomopoxviruses in West African grasshoppers from different geographical locations. Int. J. Pest Management. (In preparation).

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Tillman, P. G., J. L. Roberson, and D. D. Hardee. 1996. Disposable cardboard box for rearing/release of *Microplitis croceipes*. Southwest. Entomol. (Submitted).

3. <u>Presentations</u>:

Bell, M. R. “Present status of the large-area baculovirus program for *Heliothis/Helicoverpa* management in the Mississippi Delta.” Annual Meeting of the Southern Regional Project S-265, Development of Insect Pathogens for Use in Insect Pest Management, Orlando, FL, February 1996.

Bell, M. R. “Microbial control of insects pests.” Seminar presented to class from Louisiana State University, Stoneville, MS, March 1996.

Bell, M. R. “Commercial microbial control -- what does the future have in store?” Seminar given to the Department of Entomology, Mississippi State University, Mississippi State, MS, April 1996.

Hardee, D. D. "Crop protection products outlook -- insecticides and fungicides." Beltwide Cotton Production Conferences, Las Vegas, NV. January 1996 (Invitation).

Hardee, D. D. "High impact research and extension projects -- tobacco budworm option: area-wide strategy." Delta Council Special Briefing on Cotton Issues, 1996 Beltwide Cotton Production Conference, Nashville, TN, January 1996. (Invitation).

Hardee, D. D., and M. R. Bell. "Six years of area-wide management of bollworm/budworm with pathogens--what does it mean and where do we go from here?" Beltwide Cotton Prod. Conferences, Nashville, TN, January 1996.

Hardee, D. D. "Update on Elcar -- research, results, and future of programs." 23rd Meeting of Mississippi Agricultural Consultants Association, Mississippi State, MS. February 1996. (Invitation).

Hardee, D. D. "Noctuid area-wide control with viruses," 3rd National IPM Symposium/Workshop, Washington, DC. April 1996. (Invitation).

Hardee, D. D. "Area-wide management of tobacco budworm and cotton bollworm with aerially-applied insect viruses in the United States." XXth International Congress of Entomology, Florence, Italy, August 1996. (Invitation).

Hardee, D. D. "Bt resistance monitoring." Monsanto Bt Cotton Review, Atlanta, GA, October 1996. (Invitation).

Hardee, D. D. "Monitoring for Bt resistance." Cotton, Inc. Crop Management Seminar, Jackson, MS, October 1996. (Invitation).

Lambert, L. "Status of host plant resistance in soybean." 1996 Joint Conference of Mississippi Agricultural Pest Management Association, (Mississippi Entomological Association, Mississippi Weed Society and the Plant Pathology/Nematology State Association), Greenville, MS, February 1996.

Scott, W. P., G. L. Snodgrass, and D. A. Adams. "Mortality of tarnished plant bug and boll weevils to Provado and different formulations of Fipronil." Beltwide Cotton Insect Research and Control Conference, Nashville, TN, January 1996.

Scott, W. P. "Tarnished plant bug research with Fipronil." Mid South Cotton Technical Seminar, Rhone Poulenc Ag Company, Memphis, TN, January 1996.

Scott, W. P. "Research on cotton in the U.S." Fipronil/Balance Update Meeting, Mexico City, Mexico, July 1996.

Scott, W. P. "Evolution of temik use in cotton in the U.S." Cotton Global Training Seminar, Rhone Poulenc Ag Company, Raleigh, NC, October 1996.

Smith, M. T., D. J. Lanham, and R. D. Hennessey. "*Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* Bellows and Perring (Homoptera: Aleyrodidae): Behavioral analysis of two geographic populations." Beltwide Cotton Production and Research Conf., Nashville, TN, January 1996.

Smith, M. T. "Pecan and cotton aphid biological control." Joint Conference of Mississippi Agricultural Pest Management Association (Mississippi Entomological Association, Mississippi Weed Society and the Plant Pathology/Nematology State Association), Greenville, MS, February 1996. (invitation)

Smith, M. T. "Trap cropping system for control of Hemipteran pests in pecan: A progress report." 89th Southeastern Pecan Growers Association Convention, Predido, AL, March 1996.

Smith, M. T. "Biological control of *Bemisia tabaci* (Gennadius) and *Bemisia argentifolii* Bellows and Perring: An overview of efforts in the United States." 5th Symposium on Biological Control in South America (SICONBIOL), Foz de Iguassu, Parana, Brazil, June 1996. (invitation)

Smith, M. T. "Trap cropping system for control of Hemipteran pests in pecan: A progress report." Entomological Society of America Meeting, Louisville, KY, December 1996.

Snodgrass, G. L., and W. P. Scott. "Seasonal changes in pyrethroid resistance in tarnished plant bug populations of the Mississippi Delta." Beltwide Cotton Insect Research and Control Conference, Nashville, TN, January 1996. (Poster)

Snodgrass, G. L. and W. P. Scott. “Pyrethroid resistance in tarnished plant bug populations in the Mississippi River Delta of Arkansas, Louisiana, and Mississippi. Delta Agricultural Exposition, Cleveland, MS, January 1996.

Snodgrass, G. L. and W. P. Scott. “Seasonal changes in pyrethroid resistance in tarnished plant bug populations in the Mississippi River Delta.” Southeastern Branch Meeting ESA, Biloxi, MS, March 1996. (Poster)

Snodgrass, G. L. “Pyrethroid resistance in the tarnished plant bug: A major problem in cotton insect control in the Mississippi Delta.“ Advanced Cotton Pest Management Seminar, Mississippi State, MS, March 1996.

Snodgrass, G. L. and W. P. Scott. “Seasonal changes in pyrethroid resistance in tarnished plant bug populations over a two-year period in the Mississippi River Delta.” 43rd Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1996.

Streett, D.A. “Grasshopper virus field trial in McKenzie County, North Dakota.” Grasshopper Management Board Review. Rapid City, SD, January 1996.

Streett, D. A. “The cooperative grasshopper integrated pest management project: Research highlights from an insect pathologist.“ Sigma Xi Lecture Series. Stoneville, MS, March 1996.

IV. PLANNED RESEARCH CALENDAR YEAR 1997:

A. *NARRATIVE:*

1. In-House

Incumbent will retire from active federal service effective 3 January 1997; however, present plans include collaborating with ARS in two primary areas: the development of a larger area-wide early season pest management program, and investigating the use of the nuclear polyhedrosis virus from the beet armyworm for control of the pest in various areas of the cotton belt. This would include possible use of various formulations to increase the effectiveness of the virus, as indicated in small trials in 1995, and new and cost effective methodology for virus production. **(M. R. Bell)**

The Stoneville Insect Rearing Research Support Group will maintain six insect species in 1997. These are tobacco budworm, bollworm, soybean looper, beet armyworm, *Cardiochiles nigriceps,* and *Cotesia kazak*. Also, assistance will be given to individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30 ml plastic cups and 3.8 liter multicellular trays. Efforts will continue with infusing wild moths into colonies and developing lidding for a disposable multicellular larval rearing tray. The training in insect rearing techniques and the transfer of technology provided to industry will continue. As always, efforts will continue to produce high quality insects at the most economical price possible. The research of approximately 150 scientists within USDA-ARS, private industry, and state universities will be supported by the work of this group. **(R. L. Ford)**

The insect distribution programs with the Cotton Foundation and the United Soybean Board will continue in 1997. Both programs are expected to be utilized heavily by researchers throughout the United States. Funds provided by these programs will be used to defray insect rearing expenses of the SIML. The eggs, pupae, and larval stage of tobacco budworm, bollworm, soybean looper, beet armyworm, and velvetbean caterpillar will be available. **(R. L. Ford)**

Greenhouse and laboratory studies on effect of aldicarb on cotton aphid resistance to insecticides will be expanded to verify previous conclusions. **(D. D. Hardee)**

Various new boll weevil attract-and-kill devices supplied by commercial companies will be evaluated to determine their effectiveness in comparison with commercially available devices and traps. **(D. D. Hardee)**

A boll weevil emergence and movement study (in cooperation with G. D. Jones, USDA--ARS, College Station, TX) will be repeated to determine extent of movement of boll weevils after July 1 in close proximity to and 1-3 miles from cotton. **(D. D. Hardee)**

A study of influence of cotton aphids on ultimate yields of cotton by spraying cotton twice beginning prior to squaring, at first 1/3-grown square, and at first bloom will be repeated using transgenic and nectariless varieties of cotton. **(D. D. Hardee)**

A large-scale study involving the interaction of biological insecticides, area-wide spraying of viruses, and transgenic cotton will be initiated. Sub-plots will be in corn and cotton inside or outside the virus-treated zone in the Delta. **(D. D. Hardee, D. A. Streett)**

Monitoring of resistance to *B.t.* products and transgenic cotton to cotton bollworms and tobacco budworms will be expanded to include colonies of these insects collected in *B.t.* cotton, non-*B.t.* cotton, and corn from as many areas as possible across the Cotton Belt. This will include applications of MVP II insecticide to cotton in a spray chamber, as well as MVP II, Cry IA© protein (from *B.t.* cotton) and Cry IA(b) protein (from *B.t.* corn) incorporated into diet. The objective will be to determine susceptibility levels for possible detection of beginning tolerance or resistance in the field to these products. **(D. D. Hardee)**

Studies will be initiated on the effectiveness of a patentable product made from surface-modified mineral particles against cotton insects, with emphasis on the cotton aphid. **(D. D. Hardee and cooperators)**

Studies will be continued to determine the influence of soybean plant maturity on insect resistance. **(L. Lambert)**

Evaluations of the USDA-ARS soybean germplasm collection will continue in an effort to identify resistance soybean damaging insects. **(L. Lambert, T. C. Kilen)**

Studies will be continued with soybean to determine the influence of irrigation of soybean on the development of soybean looper populations and the subsequent impact on yield. **(L. Lambert, L. Heatherly)**

Studies will be continued on the inheritance and development of resistance to foliar feeding insects in soybean and to develop high yielding, insect resistant, soybean cultivars. **(L. Lambert, J. Tyler)**

Efforts will continue to identify resistance in cotton to foliar feeding by beet armyworm. **(L. Lambert, W. R. Meredith)**

We will continue in the annual evaluation of the Soybean Regional Host Plant Resistance Nursery for resistance to foliar feeding insects. **(L. Lambert)**

Fipronil will be evaluated in replicated large (one acre) plots for control of the tarnished plant bug and boll weevil in cotton. Populations of beneficial arthropods will be monitored throughout the test. Fipronil treatments will be compared to a standard (Vydate) treatment and an untreated control. **(W. P. Scott, G. L. Snodgrass)**

In cooperation with Fred Cooke, insect populations will be monitored and data collected in 15 to 20 locations across the Mississippi Delta in association with the economics of producing Bt and non-Bt cotton. **(W. P. Scott)**

Spray table tests will continue to evaluate Fipronil applied at different rates on resistant plant bug populations. **(W. P. Scott, G. L. Snodgrass)**

Tarnished plant bug sampling and thresholds will continue to be studied for the 3rd year. This research is funded in part by Cotton Incorporated. The recommended thresholds of plant bugs sampled by drop cloth, sweep net, and visual methods and their effects on yield will be evaluated. **(W. P. Scott, G. L. Snodgrass)**

In-furrow and sidedress studies of various recommended treatments will be continued to further evaluate treatment effects on early season cotton pests and yield in Bt and non-Bt cotton varieties. **(W. P. Scott)**

Investigations to determine the utility of a trap cropping system designed to intercept migrating stink bug species as they move from soybean and other host plants to pecan in late season will be

continued. Replication of the 1995 and 1996 tests will be performed in order to: (1) validate trap crop efficacy in reducing stink bug damage; (2) validate the damage assessment methodology; and (3) verify and/or refine the monitoring method for timing insecticide application of stink bugs in the trap crop. Comparative investigations of speckled purple hull pea and zipper cream pea as trap crops will be repeated for a second season. In concert, several additional trap crop plants will be evaluated, with an emphasis on drought tolerance, early season trap crops (i.e. Group 3 beans as a trap crop for Group 4 & 5 beans) and late season trap crops (i.e. Group 7, 8 & 9 soybeans, okra, and mustard/turnip greens as trap crops for pecans). A concerted effort will be made to develop season-long data on pecan nut damage resulting from stink bug feeding based upon nut phenological development and stink bug population density. Initial efforts will also be made in the area of biological control of stink bugs, specifically parasitoids. **(M. T. Smith, G. L. Snodgrass, B. Horton, T. Jenkins, M. Hughs, T. Winters)**

Research investigations of mating disruption will be continued in 1997. The specific objectives will once again be: (1) to evaluate the placement of the mating disruptant within the tree canopy; (2) to evaluate the dosage of the mating disruptant; and (3) to evaluate the comparative efficacy of two mating disruptant formulations, spirals and sprayable, to disrupt mating. Evaluation of mating disruptant efficacy will again be based upon the measurement of three parameters: (1) numbers of male moths trapped within sex pheromone baited traps; (2) percentage of female moths mated; and (3) nut damage. Efforts will also be made to analyze and publish the seasonal and spatial distribution data, as well as the mating disruptant release rate data. **[M. T. Smith, C. Yonce (USDA-ARS), S. Galindo (pecan grower), J. White (Ecogen)]**

Investigations of parasitoids of the silverleaf whitefly, *Bemisia argentifolii*, will be continued. These studies will include: (1) continuation of the state-wide survey of whitefly and associated parasitoid species in Mississippi; (2) evaluation of interspecific interactions among parasitoid species (S. Naranjo, G. Jackson, M. Hunter); (3) continued efforts towards the joint research program with Dr. Regina Vilarinho de Oliveira (EMBRAPA, CENARGEN, Brasilia, Brazil), where the primary objective is to explore for and evaluate New World parasitoid species for control of *B. argentifolii;* (4) development of a CRADA with APHIS and HydroGarden, Inc.; and (5) genetic evaluation of the 4 *E. formosa* strains in order to develop potential markers that may be used to differentiate these strains, which in turn could be utilized in monitoring their genetic stability as it relates to

parasitoid efficacy [Drs. C. LeVesque and T. Perring (UCR)]. **(M. T. Smith)**

Evaluation of aphid damage to cotton as a function of cotton developmental phenology, aphid density and various agronomic factors will be initiated. **(M. T. Smith, others)**

Investigations will continue of the seasonal successional phenology of key legumes (clover species in particular) which are native to the Mississippi Delta. The objective of this investigation is to develop a season-long succession of cover crops as refugia for natural enemies of pecan aphids. **(M. T. Smith, T. Jenkins)**

Analysis of biological and behavioral performance data on all three aphid species on each Juglandaceae species and pecan cultivar will be completed. **(M. T. Smith)**

Analysis of leaf chemistry of each Juglandaceae species and pecan cultivar will be continued. **(O. T. Chortyk, M. T. Smith)**

SEM analysis of the potential role of leaf surface and/or internal morphology in host plant resistance among the Juglandaceae species and the various pecan cultivars will be completed. **(M. T. Smith, Rex Paul)**

Development of an artificial diet bioassay method for evaluation of phytochemicals (natural products) isolated from the various non-preferred or unsuitable Juglandaceae species and/or pecan cultivars will be continued. **(M. T. Smith)**

Investigations to elucidate the mechanism(s) which govern the host specificity of *M. caryella, M. pecanis* and *M. caryaefoliae* among the hickory and walnut species native to the United States, as well as among the pecan cultivars, will be conducted utilizing grafted plants of each Juglandaceae species and pecan cultivars. **(M. T. Smith, C. C. Reilly, B. W. Wood)**

Research may be conducted to evaluate several entomophathogenic nematodes for control of the pecan weevil. **(M. T. Smith, R. W. Martin, J. Kuhre)**

We will investigate the unique factors (biotic and abiotic) which prevent the pecan weevil from becoming established in the Mississippi Delta region of the pecan belt, and which might have application in other pecan growing areas outside the delta and in other states. **(M. T. Smith, T. Jenkins)**

Insecticide resistance monitoring will be conducted in 1997 using a discriminating dose (15 μg of permethrin) glass vial bioassay and plant bugs collected from wild hosts at 71 locations in the Delta in the spring and fall of 1997. The collection locations will be the same ones used in 1995 and 1996, and results of the 3 years will be compared to detect changes. This work is partly funded by a grant from Cotton Incorporated. **(G. L. Snodgrass, W. P. Scott)**

A large field experiment will be conducted using cotton in a commercial field. The experiment is designed to test treatment thresholds and associated sampling methods used to determine them (as recommended by the Mississippi Cooperative extension Service) to see how well they work. The work is partly funded by a grant from Cotton Incorporated. **(G. L. Snodgrass, W. P. Scott)**

Responsiveness of mutant red-eyed plant bugs to different wavelengths of light will be compared to determine if vision in the red and normal eyed bugs is the same. Adults and nymphs collected in the insecticide resistance study (discussed above) will be examined for red eyes to help determine the natural occurrence of the mutant trait. **(G. L. Snodgrass)**

Research will be conducted to assess the effect of formulation on the efficacy of *Autographa californica* NPV and *Helicoverpa zea* NPV against *H. zea/H. virescens* in cotton. Data will be collected to evaluate a) percent larval infection; b) larval numbers; c) virus persistence. **(D. A. Streett)**

An area-wide management program with *Helicoverpa zea* nuclear polyhedrosis virus will be conducted on 201,000 ac in the Delta to control the first generation of bollworm and tobacco budworm. It is our intention to evaluate the impact of a lower virus application rate that may still provide adequate suppression of the pest population. **(D. A. Streett)**

A monitoring program will be established to assess lepidopteran resistance to *Bacillus thuringiensis* insecticidal proteins. Four sites in the Mississippi Delta have been identified for extensive sampling of

Helicoverpa zea and *Heliothis virescens*. A diagnostic dose will be calculated for *H. virescens* and *H. zea* and then used in testing for *B.t.* resistance. **(D. A. Streett)**

2. <u>Extramural</u>

Cooperative studies will continue to determine the significance of sound production of fire ants. **(L. Lambert, R. Hickling)**

Persistence studies of baculovirus on early season alternate hosts of tobacco budworm/cotton bollworm (2 species of wild geranium and velvetleaf) will continue in cooperation with the University of Arkansas to be studied through field bioassays. This consists of treating the plants with known concentrations of virus and feeding plant material to larvae at various times after treatment. Because of the reduced persistence obtained in the previous study, these tests will also be designed to determine if there is a difference in persistence due to the virus formulation used. Similar tests will also be conducted on cotton and soybeans as soon as they are available in the field. **(D. A. Streett)**

In cooperation with DuPont, we propose to evaluate the impact of a recombinant virus against tobacco budworms and bollworms in cotton during 1997. The effects of prevalence, mortality, and persistence will be assessed to determine effectiveness. **(D. A. Streett)**